



THE COMMUNICATOR SURREY AMATEUR RADIO CLUB



Volume II

April 2009

Issue XXXVII I

VE7SAR

VE7RSC

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Surrey Amateur Radio Club

**ALWAYS MONITOR 147.36+ (110.9)
OR 443.775+ (110.9 in and out) IRLP 1463**

CLUB NET @ 8:00 P.M. Tuesday 147.36+ (110.9)

Thursday 144.250 USB 7:30 P.M.

CLUB MAILING ADDRESS : 239 -7156 121 St. Surrey, B.C. V3W 0J6

The next meeting of the Surrey Amateur Radio Club will be held on Wednesday May 6th 2009 at the Provincial Regional Emergency Operations Center (PREOC) located at 14275 96th Avenue Surrey V3T 4M5 - Enter off 96th Talk in on 147.36+ (110.9) 443.775+ (110.9)

Minutes for April 1, 2009 SAR Club meeting

1. Meeting was called to order at 7:30 pm April 1, 2009. 21 people were in attendance at the Surrey PREOC building. Welcome to our guest speakers, John MacFarlane VE7AXU and Bill Gipps VE7XS

2. John Brodie VE7JBB gave a brief Treasurer report. Checking account balance \$1975, ING account balance \$3437, Total \$5412. Outstanding to be paid approx \$200 for Ham Class facility rental and upcoming insurance of approx \$150.00.

3. Flea Market Report by Wayne VE7HM. It was a successful day with approximately \$500 made. A tentative booking has been made at the Sullivan Hall for next year Mar 28, 2010. Attendance was approximately 150. Fred Orsetti added another \$40.00 was made from a donation of Al Neufeld's equipment sales. A special thanks to our Kitchen crew and volunteers.

4. Repeater report. Steve VE7MAN has a 220 repeater ready to install and with Dave Cameron assisting with tuning the cans. A motion was made by Mike VE7AT to allow the pur-

chase a Sinclair 220 antenna. Seconded by John VA7XB. Motion passed.

5. Welcome to John VE7AXU who gave an interesting presentation on Ham Logging Programs, with a brief orientation for beginners.

ACLOG by N3FJP

MIXW

DX Labs Suite

Nimm

Ham Radio Deluxe were all discussed with a PowerPoint presentation.

Coffee Break

6. Bill Gipps presented a talk on his Belize DXpedition. From Bill's presentation "HolyCow Batman! I called CQ and the world answered" was an inspiring presentation on the adventure he enjoyed in Belize at www.wishwilly.net

7. 50/50 Draw. \$15.00 prize winner Gord VE7GRK

A digital multimeter donated by Kjeld was won by Bill Gipps.

John VE7AXU



John Macfarlane VE7AXU/VA7PX presented several logging programs and their respective pros and cons.

John talked on Write-log, MixW, N3FJP, N1MM and Hamradio Deluxe giving us and overview. He touched on the use of Macros and how each program used the code in different ways. He compared each program strengths and weaknesses and showed how one program may be more suited to a particular need, such as contesting.

John pointed out that some logging programs are free and some cost a few dollars. Hamradio Deluxe is a popular and powerful program that is free for the downloading. N1MM is also another free program and is somewhat complicated to get up and running. This program is very robust for contesting and is used by many testers because of its features.

The programs that have to be purchased are MixW and Writelog. MixW is a great program well supported and is used a lot by hams operating PSK31 and other digital modes. The cost is \$50.00 USD but the authors provide updates at no cost.

WriteLog is another program that requires purchasing and I am not sure what the current cost is it used to be \$60.00 USD. WriteLog is another program used by DXpeditions and testers. WriteLog charges an annual fee for updates and can get quite expensive.

N3FJP has a number of programs for various needs such as general logging and many contests including Field Day. SARC used this logging program for several years and it worked well for networking computers. Scott, the author of N3FJP charges for each module or you can by the entire package for \$49.00 USD and he provides all the updates at no additional cost.

If you need more information on any of the programs John talked about please get in touch with him.

Bill Gipps VE7XS



Bill Gipps VE7ISV/VE7XS, who has just taken over as BC/Yukon Director for RAC, gave us a brief outline of some of the items he will be dealing with in the future. Bill steps into the role of Director following Ed Frazer who was director of two terms. We wish Bill success in his endeavors to represent BC/Yukon amateur radio operator's interest.

Bill had a mini DXpedition to Belize recently and had a Power Point presentation on his activities which we all enjoyed. Bill spent roughly two weeks on Belize and operated as V31BG making over 4200 Q's. He plans to return to Belize soon with some of his own gear and hopes to overcome some of the operating issues he faced on the first trip.

The presentation covered the operating site, which was a turn key operation, and some of the surrounding area.

For those who worked him he has QSL cards if you would like to confirm your contact. Bill operated most bands on SSB and plans to expand his next operation to CW and possibly RTTY.

We all wish you well in your new role as RAC Director and hope to hear you in the pile up on your next trip to Belize.

Some websites

For those who want to check out some of the logging programs that John was discussing:

WriteLog; <http://www.writelog.com/>

N1MM: <http://pages.ctime.net/n1mm/>

N3FJP: <http://www.n3fjp.com/>

MixW: <http://www.mixw.net/>

Hamradio Deluxe: <http://www.ham-radio-deluxe.com/>

You can check out Bill's website for Belize; http://www.ve7isv.com/belize_2008.htm

His website as RAC director
http://www.southgatearc.org/news/march2009/new_bc_yk_regional_director.htm

Field Day 2009



Field Day 2009 is fast approaching and Anton James

VE7SSD is looking for operators for the last weekend in June. Field Day is a great way for everyone, especially new hams, to get some operating experience and have fun at the same time. If you would like to participate in the SARC Field Day 2009 contact Anton at jamesadf@shaw.ca

SARC spring Flea Market



Wayne Muster VE7HM swap meet coordinator handled all the arrangements.



Announcing that Bill Gipps, VE7XS will be taking over from Ed Frazer, VE7EF.



Ed Frazer handing the Director reins to Bill Gipps



Kathy and Jane handling the kitchen duties and Mike enjoying a hot dog plus



There was a good turnout and the weather was very cooperative.

Two of our newest club members who are working on their ham license



Mike, VE7AT, presenting Jim VE7PS with the grand prize



SARC Ham Class

SARC completed the second ham class and graduated new amateur radio operators. A second tutoring session and re-write of the exam was held in early April with good results. The new hams seem to be keen on getting on the air and hopefully they will participate and enjoy the upcoming Field Day.

Congratulations to everyone who worked so hard and now can enjoy the wonderful hobby of amateur radio.

SARC Repeaters

Both the VHF and UHF repeaters are functioning well thanks to the work done by Steve Coleman VE7MAN.

Don't forget the UHF repeater has IRLP installed the node number is 1463. If you are out of town you can find an IRLP node and bring up our UHF repeater.

Drew VA7DRW Heads for MOAB

It's that time of year again, I will be heading off for Moab Utah again. I have just finished setting up a mobile HF station in my truck and am hoping to be able to make some contacts along my travels and keep in touch. I will be monitoring 20 meters during the day around 14.250 MHz and would like to setup a sked for 1700 and 2100 UTC. I will also be attempting to check in to the [BC public service net](#) and [BC/Yukon NTS Traffic net](#) on 80 meters daily. Band conditions permitting I should be available for contact after the nets.

I should also be available via IRLP, when I'm in Utah Node [3270](#) which is located in Castle Dale is linked full time to the [Sinbad](#)

[Desert Amateur Radio Club's](#) linked repeater system. I should be in range of the Abajo Peak or Bald Mesa linked repeaters for the majority of my time there and will be monitoring them.

I will also be using APRS [VA7DRW-12](#) and Airmail [va7drw@winlink.org](#)

I should be leaving home the morning of Wednesday, April 22nd and arriving in Mexican Hat in south east Utah on Friday, April 24th. I will be playing around in that area until Monday, April 27th where we are planning on spending the night around Monticello before moving on to Moab, late Tuesday, April 28th. I will be staying in Moab until Sunday, May 3rd when I will starting on my way back home.

73,
Drew

Mike VE7AT takes a break

As you all know by now, our President Mike VE7AT resigned last week. Mike was President for two years during which time he was instrumental in giving life to many important developments that helped put Surrey Amateur Radio Club back on the map after some lean years. During Mike's tenure, Club membership roughly tripled in size, ham classes were begun bringing many new members into the Club, and a flea market was reinstated after a decade's hiatus. The Tuesday night VHF net was revitalized, and Friday morning breakfasts initiated. In addition, the VHF and UHF repeaters, including IRLP, were upgraded at a new strategically placed location, making them available to amateurs throughout the Lower Mainland. Although Mike had help from several capable members in all these endeavours, his enthusiasm was largely responsible for making them a reality. We are grateful for Mike's leadership during the last two years and wish him well with whatever challenges he undertakes in future.

John VA7XB
VP SARC

Upcoming Events

Field Day June 27 and 28 setup will begin on Friday June 26. Contact Anton, VE7SSD at [jamesadf@shaw.ca](#)

SARC June SARC Annual General Meeting (AGM) June 3rd

HYACK PARADE Saturday May 23 Contact Ken VE7UQ at [ve7uq@shaw.ca](#)

ROTARY CLUB BIKE-A-THON Sunday July 12 Contact Ken VE7UQ at [ken-jclarke@shaw.ca](#)

Special training

Ken Clarke, VE7UQ, has arranged training for amateur radio operators who plan to come out for the Hyack Parade on May 23rd. The training will be this coming Thursday April 23rd and handled by the New Westminster Police Department. If you plan on helping with the parade this is a great opportunity to receive additional information which will help you with your communications requirements.

Please contact Ken Clarke as soon as you can so he can get you on the list for training. He can be reached at [kenjclarke@shaw.ca](#) or on his cell 604-816-5775.



Late Ham Class News

Graduating to date

Egon Frank, VA7EGO Kelvin Hall, VA7KPH Vickie Kirk, VE7VLK
Samuel Kirk, VE7SAM Arthur Siemens, VE7SIE



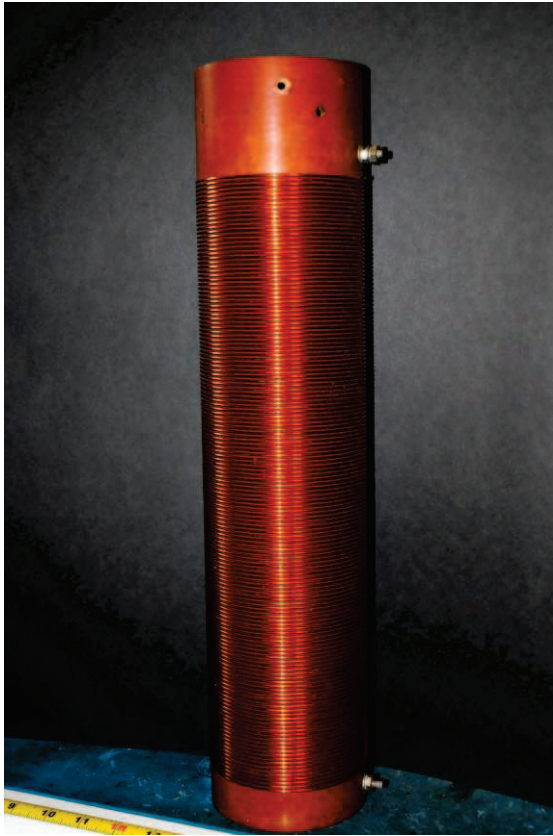
Mike VE7AT thanking Gary VE7AS and Fred VE7IO for teaching with the Ham class





With Gary W. Skett, VE7AS

Aerial Adventures



“What can you do with THAT?” The young man said, as I walked out of the swap meet with my latest treasure. “Building a crystal set or something?” I smiled and said, “No, a 80 meter rubber ducky.” I smirked, he looked totally dumbfounded. “Cool.” He said, and continued scanning the table for that bargain of a lifetime...A late model all-band transceiver at 1984 prices...

My treasure was a nothing more than a nicely preserved coil of #12 gauge copper wire on a Bakelite-looking tube. If nothing else I had at least 100 feet of wire for a dipole. But it caught my eye, as you don’t get to see nicely made coils that size too often these days. It reminded me of something I saw when I was a transmitter tech for CBC in the 70’s. Not entirely sure of its history, I was told it lived in the AM broadcast business.

What would I do with it? My immediate thought was a homebrew screwdriver antenna...but I already made one of those – Some of you may remember my red Dodge Colt hatchback with that ‘large’ screwdriver antenna and 9 foot whip on a heavy aluminum bracket off the driver’s side of the rear pane...and inside a first generation IC-706. Ah, fond

memories of many a good mobile DX QSO and several close encounters with low strung trolley lines...

In any case, if I were to use this wonderful coil, I would first need to know a little about its characteristics. Of course I could simply put an inductance meter across it and measure the microhenrys and stick one of my analysers across it and see where it resonated...but what is the fun in that? There are too many dusty old algorithms one can dig up and put to good use – and then I’ll put my meters across it and see if they prove out the math.

Step one, take measurements. The coil itself was 14.625 inches long and had a diameter of pretty close to 3.8125 inches. Counting 3 times to make sure, there were 145 complete turns – I estimated 10 turns per inch. Windings were too close to be safe for transmitting at any AM broadcast power, so it might have been a pick-up coil or something used in monitoring the AM signal.

Anyway, how many Henrys? Out of several formulae, I picked Inductance = Radius² times Turns² divided by 9 times the Radius Plus 10 times the length. It calculated out to 468 micro henrys [rounded to the nearest integer]. My meter measured closer to 500, but varied annoyingly, depending where I was positioned, while holding the meter, and the probes. Is that all? Seemed a small value for such an impressive coil.

Next, using $C=\pi D$ (Circumference = Pi times Diameter), I determined that each coil took almost a foot of wire! – 11.97732 to be precise. That meant the 145 turns would mean about 145 feet of wire. Exact figures yielded 144.726 feet of wire. Now that I had the length, I could plug it into another simple formula to get a resonant frequency. $468 \div \text{Length}$ came up with 3.233697 MHz. – darn too low for a helical antenna on the 80 metre band. About 19.25 coils to low...but close enough to play with.

Hum what's the 3rd harmonic of a station in the AM broadcast band? Is there a station on 1070 KHz.? CFAX in Victoria...Hummm, most interesting. There is about half a dozen stations in the Province between 780 to 860 KHz. – the 4th harmonic...more pondering Hummms.....So, I hooked it up to the general coverage receiver and as a receive antenna on the AM broadcast band...it was only marginally worse than my general coverage 40 foot long wire strung in my attic – although far quieter in the ambient noise received off-air...High-Q at work!

So where would the coil resonate? Hooking up to the VNA (Vector Network Analyzer) – more commonly called your “antenna analyser” I discovered that it wouldn't resonate anywhere...not entirely a surprise, as a simple coil – an inductor – by itself does not make a transmit antenna. Any resonant antenna is made up of both inductive and capacitive reactance – I was missing an important element.

So, out on the back lawn, with the coil form sitting in the neck of a large glass mason jar and a 9 foot piece of aluminum tubing vertically off the top end of the coil, I attached my centre conductor to the coil base and the coax braid to an existing set of 4 ground radials...with a bit of playing around with my AT-230 tuner, and an additional a 6 foot diameter capacity “hat” added to the top of the vertical pole I made an 80 meter CW contact



with UA0CIC on the NE coast of Russia in the area around the Kamchatka Peninsula – Sounds exotic, but it's just across the pond – as the RF flies. I had my first mobile 75 metre QSO from that piece of land too. But I digress, the point was at 100 watts the close-wound coil didn't arc and I got a pretty cool DX QSO. At sunrise I talked to my only 160 metre friend across the border [in the Cherry Point area of Washington State] on the same antenna. 4-4 copy mind you, but at least he could hear me. About 1 S-unit lower than my 160 Metre Isotron. So...yes you can put just about anything on the air...AND make a contact! More later on the coil's

life as a HF antenna.

I was going to talk about an improvement over the Copper Cactus we made a few articles ago, but this just came in as I was putting together the second part of the article, and it just far more entertaining a read and makes for some interesting daydreaming...

Underwater Radio Communication

(Originally published in Amateur Radio magazines around April of 1987)

Article pages courtesy of my new friend and new Ham, Egon Frank.

How far can we communicate underwater in the sea or in a lake. How large is the signal attenuation and what Frequency can be used? Could we use 1.8 MHz? In the following paragraphs, we attempt to answer some of these questions.

INTRODUCTION

One could ask why a radio amateur enthusiast might be interested in underwater communications. Well, one could be interested in diving and wish to set up a communications link with the surface, or perhaps he might be interested in radio controlled boats and wish to try their hand at model submarines! On the other hand, he/she might just be interested in another area of experimentation because here is a field, relatively untouched by the amateur fraternity, involving different transmission techniques, different antenna designs and different equipment environmental problems.

The scope of this article concerns the transmission characteristics of radio waves underwater and the extent to which the radio amateur might make use of these characteristics.

The article includes examination of the transmission options for what was lowest Amateur Radio frequency (1.8MHz) when the article was first published. Of course, some countries now have an LF Amateur band and the lower attenuation at LF now opens the options further.

WATER CONDUCTIVITY

Water in its pure form is an insulator, but as found in its natural state, it contains dissolved salts and other matter which makes it a partial conductor. The higher its conductivity, the greater the the attenuation of radio signals which pass through it.

Conductivity (σ) varies with both salinity and temperature. Sea water has a high salt content and high conductivity varying from 2 mhos per metre in the cold arctic region to 8 mhos per metre in the warm and highly saline Red Sea. Average conductivity of the sea is normally considered to be about 4 mhos per metre. What this means is that one metre cube of sea water has a conductivity of 4 mhos or a resistance of 0.25 ohms, (it's reciprocal).

So called fresh water has lower conductivity and as a guide to this, a sample analysis of Adelaide water taken in 1983 has been used. This sample was taken from an area principally supplied by the Barossa reservoir and the analysis shows total dissolved salts as approximately 300 mg/litre and a conductivity of 0.0546 mhos per metre. How close this is to the average waters in lakes and rivers in Australia is not known, but as it is the only water on hand, it has been used as a reference.

ATTENUATION

Attenuation of radio waves in water (and, in fact, in any conducting medium) increases both with increase in conductivity and increase in frequency. It can be calculated from the follow formula:

$$\text{Attenuation } (\alpha) \text{ in dB/metre} = 0.0173 \sqrt{f\sigma}$$

where f = frequency in hertz

and σ = conductivity in mhos/metre

Figure 1 illustrates attenuation as a function of frequency for sea water and Adelaide water. Attenuation in sea water is very high and to communicate at any depth at all, it is necessary to use very low frequencies (10 to 30 kHz) where attenuation is in the order of 3.5 to 5 dB per metre. Operation in the lowest frequency amateur band (1.8 MHz) is out of the question at 46 dB per metre.

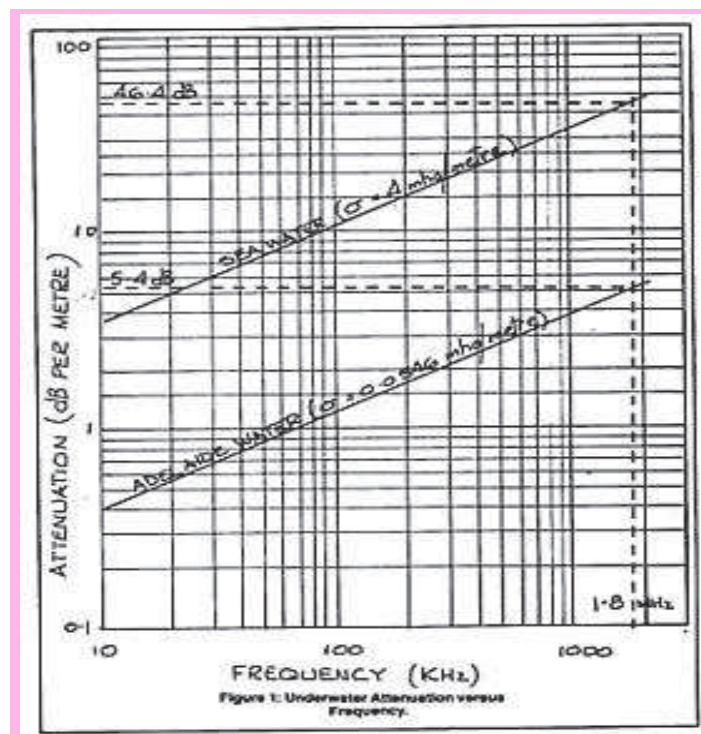


Figure 1: Underwater Attenuation versus Frequency.

The potential for operation in fresh water is much better. Using the Adelaide water sample, attenuation at 10 kHz is only 0.4 dB per metre rising to 5.4 dB per metre at 1.8 MHz.

REFRACTION OR INTERFACE LOSS AT THE SURFACE

When EM waves travel from air to water or water to air, there is a refraction loss due to the change in the medium. This loss can be calculated from the following formula:

$$\text{Refraction loss (dB)} = -20 \log \left\{ (7.4586/10^6) \times \sqrt{f/\sigma} \right\}$$

In sea water, this loss is quite high and in the vicinity of 60 dB for the low frequencies normally used. If communication is required from surface to underwater, path loss can be reduced by connecting the surface equipment to an antenna under the surface so that the refraction loss is eliminated.

Figure 2 illustrates refraction loss as a function of frequency for sea water and Adelaide water. It can be seen that refraction loss falls with an increase in frequency and in the case of the fresh water, this loss is down to 27 dB at 1.8 MHz which is quite attractive from an amateur radio point of view.

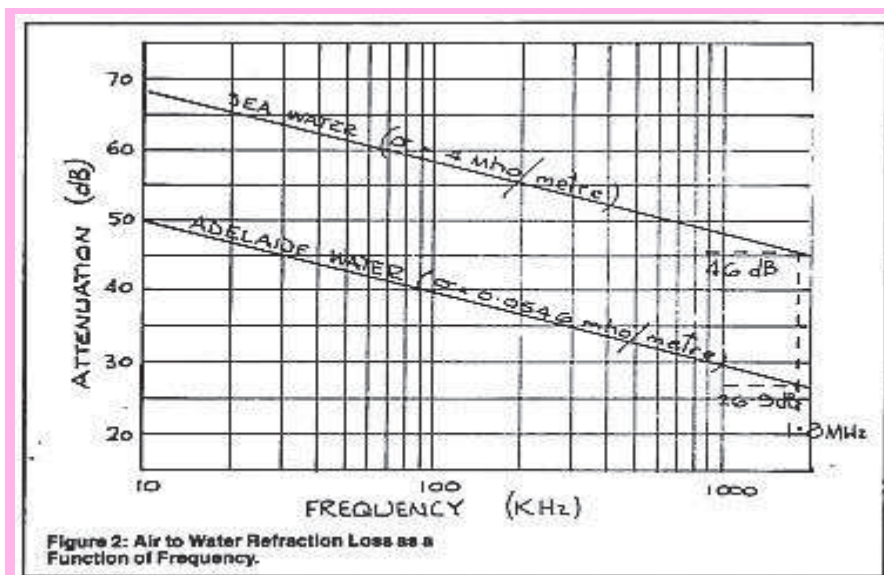


Figure 2: Air to Water Refraction Loss as a Function of Frequency.

WAVELENGTH IN WATER

The wavelength in water is but a fraction of that in space and is calculated from the following formula: -

$$\text{Wavelength } (\lambda) \text{ in metres} = 1000 \sqrt{10/(f\sigma)}$$

Figure 3 plots wavelength versus frequency. In sea water, wavelength at 10 kHz is only 15.8 metres compared to 30 km in space. In fresh water the reduction in wavelength is not so dramatic but still quite considerable. At 1.8 MHz, wavelength is 10.1 metres compared to 167 metres in space. This reduction in wavelength leads to some considerable differences in antenna engineering with an underwater dipole at 1.8 MHz being only a few metres long.

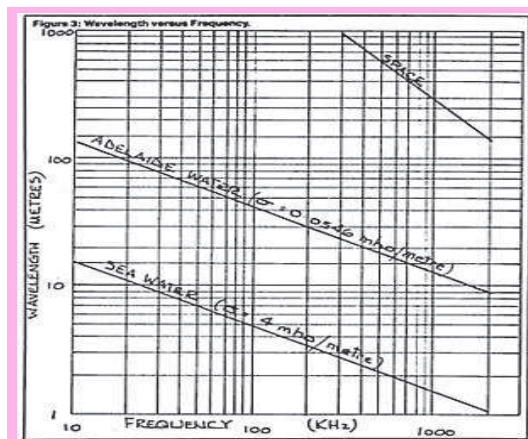


Figure 3: Wavelength versus Frequency

TRANSMISSION OPTIONS

The lower the frequency, the lower the attenuation in water and the better the potential for communications. Unless a band of frequencies could be approved for amateur use in the VLF region, the options for amateur radio are restricted to 1.8 MHz and communication in fresh water. A few transmission examples for this application will be discussed and these will be based on the following assumptions:

- 1 Radiated power is 0 dBW (referred to one watt developed in a half wave dipole). All other measurements are in decibels referred to that level.
- 2 Receiver bandwidth = 3 kHz.
- 3 Minimum discernible receive level at receive antenna = 10 dB above thermal noise (KTB) is -153 dBW (for 3 kHz bandwidth).
- 4 Atmospheric noise at 1.8 MHz = 35 dB above KTB (taken from published noise charts) i.e. -128 dBW for 3 kHz bandwidth.
- 5 Attenuation in fresh water = 5.4 dB/metre (from Figure 1 at 1.8 MHz).
- 6 Water/air refraction loss = 27 dB (from figure2)

Figure 4 shows the receiver submerged and the transmitter above the surface. The signal path is subject to 27 dB air/water interface loss. Atmospheric noise is also attenuated by the interface and path loss and minimum receive level is set by the sensitivity of the receive system (not affected by atmospheric noise). Maximum length of the water transmission path works out to 23 metres.

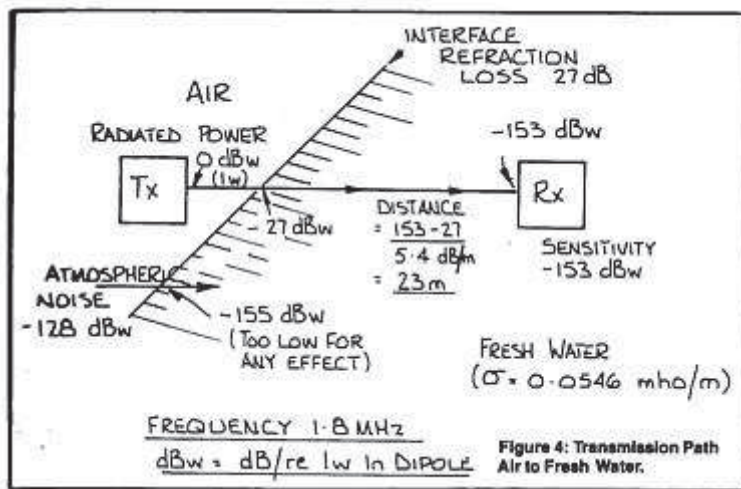


Figure 4: Transmission Path - Air to Fresh Water.

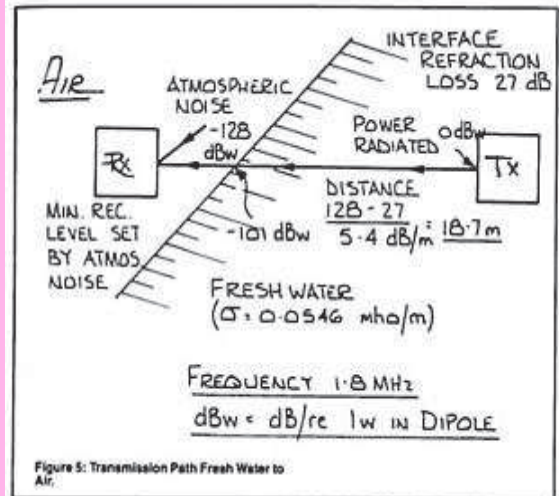


Figure 5: Transmission Path - Fresh Water to Air.

Figure 5 reverses transmission direction so that the transmitter is submerged and the receiver is above the surface. In this case the minimum receive level is set by the atmospheric noise (well above the receive system sensitivity). Because of this, the maximum length of water transmission path is reduced to 18.7 metres.

Figure 6 submerges both transmitter and receiver, eliminating the air to water interface loss of 27 dB. This extends the maximum length of water transmission path to 28 metres

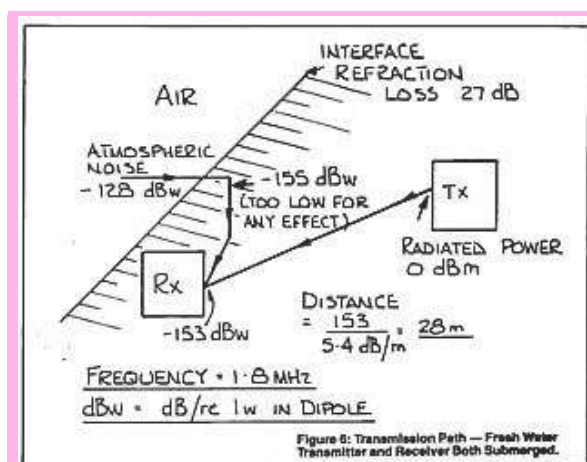


Figure 6: Transmission Path - Fresh Water, Transmitter and Receiver Both Submerged.

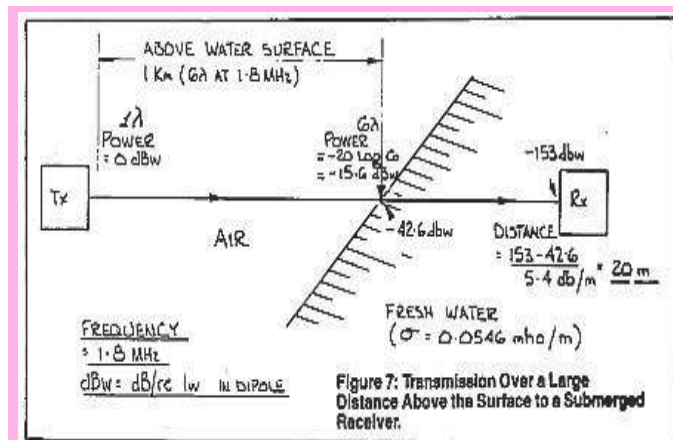


Figure 7: Transmission over a large distance above the surface to a Submerged Receiver.

We now turn our attention to transmission in space. Beyond one wavelength from the transmitting antenna, field strength in space varies inversely with distance; ie the signal is attenuated 6 dB each time the distance is doubled and attenuation from a point one wavelength from the antenna to a distance d is equal to $20 \log (d/\lambda)$.

Referring now to Figure 7, we have a transmitter with a reference power 0 dBW at one wavelength and this point is 1000 metres (or six wavelengths) from the water surface. Power level at the air/water interface is $-20 \log 6 = -15.6$ dBW and transmission for a further 20 metres underwater is still possible.

Taking this type of transmission a little further, we now examine Figure 8. Here we have both transmitter and receiver below the water surface but 1000 metres apart. Communication over this distance via the water path is impossible but the signal can leave the water near the transmitter, travel via the air path and re-enter the water near the receiver. The signal suffers the interface loss twice (ie 54 dB) but attenuation over the 1000 metres is limited to that of the air path. So here is another technique by which two underwater stations might communicate over quite a large distance, limited essentially by the depth in water at which the stations are based.

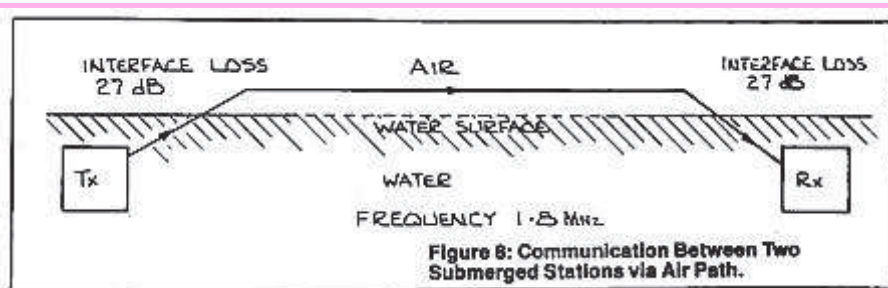


Figure 8. Communication Between Two Submerged Stations via Air Path.

In the examples given, actual transmission distance underwater is limited from 18 to 30 metres. This distance can be increased by increasing power or decreasing frequency. Increasing the radiated power to 100 watts would give 20 dB gain or an extra underwater distance of 3.7 metres (not a large increase). If a frequency of 100 kHz were available, attenuation would be 1.28 dB/metre and taking the example of Figure 6, distance would recalculate to the greater value of 120 metres. At this frequency, however, interface loss increases to 40 dB and in the example of Figure 4 (which includes interface loss) the distance would be a lesser 88 metres, but still greater than for 1.8 MHz.

Another point to consider, is that Adelaide water is not renowned for its purity of dissolved (or undissolved) matter and it is possible that water in lakes and rivers elsewhere might have lower conductivity than that of the Adelaide sample.

ANTENNAS

Design of underwater antennas is beyond the scope of this article, but a few interesting details can be discussed. Published references indicate that loop antennas, long wires and dipoles have been successfully used underwater at very low frequencies, their physical dimensions, in terms of a space wavelength, being much less than their equivalent in space.

Antenna conductors are insulated from the water to prevent leakage current direct to the conducting medium, but there is still coupled conduction into the medium which causes the radiation resistance to be considerably lower than that of the equivalent antenna in space. A radiation resistance of a few ohms can be expected for a half wave dipole.

There is also the question of polarisation and directivity. According to Moore(ref.2), a submerged horizontal electric dipole is equivalent in its field to a weaker vertical antenna at the surface. Most of the energy, radiated upwards from the antenna, is refracted at the surface into a vertically polarised, almost horizontally travelling wave, above the surface. This phenomenon helps to explain the technique used in Figure 8 to transmit signals horizontally above the water surface and to receive them in the reverse process.

Moore also points out that attenuation between one side of the submerged antenna and the other, is so great that a major contribution to the field at any point is primarily due to the nearest point on the antenna. Thus coordinates on an antenna pattern in a conducting medium are meaningless. There is, of course, a null off the end of a dipole and hence horizontal dipoles are more satisfactory than vertical dipoles for communication via the surface.

Antennas used in the sea have made use of the conducting sea as the actual radiating element. The signal is either coupled to the sea via connecting electrodes or by inductive coupling from an

insulated loop. These techniques are possibly impractical for fresh water with much lower conductivity.

SEA WATER

As discussed earlier, attenuation of radio signals in sea water is so great that communication further than just below the surface is not possible unless very low frequencies (10 to 30 kHz) are used. Even if permission could be obtained to use frequencies in this band, there are other difficulties facing the amateur enthusiast:

1 Air to water refraction loss in this band is in the order of 60 to 70 dB.

2 Massive antenna dimensions are required, particularly for the above the surface antenna. (Even at 30 kHz, a wavelength is 10 km). Large transmitter powers are usually required to compensate for the high antenna losses inherent in the shortened low frequency antenna.

3 Atmospheric noise peaks to about 160 dB above thermal noise (KTB) at 10 kHz, limiting the minimum discernible receive level.

OTHER CONDUCTING MEDIUMS

Whilst the discussion has concentrated on transmission through water, the theories outlined can equally be applied to other conducting mediums such as the earth's crust. Typical applications include radio communications in underground shafts and caves.

The conductivity of the earth's crust varies widely with conductive over-burden between 10^{-4} and nearly 1 mhos per metre and low conductivity rock less than 10^{-5} mhos per metre. Quite clearly, the success of the underground communications depends on the geological make up of the surrounding terrain.

CONCLUSIONS

Radio communication under the sea is not an attractive option for experiment by the radio amateur as it requires the use of very low frequencies, large antenna systems and very high powers.

Fresh water lakes and rivers have much lower electrical conductivity than the sea and underwater transmission distances (or depths) up to 30 metres appear feasible using the lowest frequency amateur band of 1.8 MHz. Even larger distances (or depths) could be achieved if a lower frequency band allocation is available. *(Attenuation at 180 kHz is reduced to around 18 dB per metre in seawater and around 2.2 dB per metre for fresh water.)

Communication between underwater stations or between a surface station and an underwater station could be achieved over much larger distances by utilising a transmission path above the surface and tolerating the air to water refraction loss.

Similar communications could be carried out from underground depending on the conductivity of the surrounding over-burden or rock.

***Footnote** Since this article was first published, a number of countries have since allocated amateur bands in the region of 130 to 190 kHz providing a better medium for underwater transmission than 1.8 MHz.

REFERENCES

1 Reference data for radio engineers, ITT Chapter 27. Radio noise and interference.

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SYMBOLS used In Text

σ (sigma) - Electrical conductivity (mhos/metre).

f - Frequency (Hertz).

λ (lambda) - Wavelength (metres).

dB - Decibels.

dBW - Decibels reference one watt.

α (Alpha) - Attenuation constant (dB/metre).

d - Distance (metres).